Equilibrium Exchange Rates in Asian Currencies

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In this paper, we measured the equilibrium exchange rates (EER) for Asian currencies (baht, new Taiwan dollar, won, yen, and yuan) and the U.S. dollar. We compared the equilibrium exchange rates reflecting economic fundamentals with the actual exchange rate, and examined which factors affect the movement of equilibrium exchange rates. Our study shows that rapid increases of labor productivity in Korea and China have prevented an excessive depreciation of the won and yuan. When we take multilateral trade into account, the effective exchange rate of the yen was undervalued compared with the effective equilibrium exchange rate in 2000.

Keywords: Asian currency crisis, Equilibrium exchange rate, Hollowing out of industry, Productivity differences, Purchasing power parity

JEL Classification: F31, F40, L60, O53

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I. Introduction

Since the collapse of the asset bubble in the beginning of the 1990s, the Japanese economy has been suffered from long-term economic stagnation. During the same decade, however the other Asian countries attained high economic growth rate, although Asian currency crisis in 1997-8 brought some instability to some of these countries. Under such a contrast, some economists have pointed out that "hollowing out of the Japanese industries" induced by the rapid development in the other Asian countries, was one of the causes in the long-term stagnation of the Japanese economy. This is because Japanese firms moved to the other Asian area where the production cost was lower than Japan.

In discussing "hollowing effect of industries," we have to consider whether the present exchange rate is an appropriate measure of the international competitiveness of industries. In the first half of the 1980s, Japanese export to the U.S. grew sharply, causing trade friction. Calculating the equilibrium exchange rate (hereafter referred to as EER) which we will discuss below, Yoshikawa (1990) explained that the sharp increase in Japanese exports was caused by the overvaluation of the U.S. dollar. At that time, the U.S. economy was suffering from "hollowing effect of industries" and lost international competitiveness. In that sense, the U.S. economy in the first half of the 1980s provides some important lessons for our understanding of the Japanese economy in the 1990s.

Now, we focus not only on the exchange rate against the U.S. dollar, but also on the exchange rates against the other Asian countries because Asian countries have become big trade partners. In particular, the growing presence and current account surplus of the Chinese economy has influenced the world economy. Many countries pay attention to the U.S. dollar peg system of the yuan, and are interested in finding a long-run equilibrium rate when China moves to a more flexible exchange rate system. Furthermore, many Asian countries have positive attitudes toward Free Trade Area (hereafter FTA). However, if their home currency is overvalued compared to their EERs, FTAs are likely to be disadvantageous for industries in the home country. Thus, we require a reliable estimate of the EER to understand the effects of FTA on international competitiveness of industries.

To understand the above topics in an academic perspective, we will measure the EERs of five Asian countries (China, Japan, Korea, Taiwan, and Thailand) and the U.S. and consider the international competitiveness among those countries. The reasons why we selected these countries are as follows. First, these countries have relatively similar industrial structures, unlike those of Singapore and Hong Kong. Second, these countries have had close trading relationships.[1] Third, the statistical data that we require for measurement of EER is available in these countries.

Our paper is constructed as follows. In the next section, we measure the EER among five Asian countries and the U.S., along the concept of Yoshikawa (1990).[2] In Section III, we examine which factors affect the movement of the EER. In particular, we focus on the effects of productivity differences between two countries. In Section IV we propose alternative measures of the EER. First, we discard the assumption that the cost of capital is equal internationally and add capital service as a new factor of production. Second, concerning the EER of the won, we take the intermediate input from the service sector into account. Third, because the original concept of EER is based on bilateral trade, we will measure the effective EER based on multilateral trade. In the last section, we summarize our results and state some remarks for future studies.

II. The Measurement of EER Based on Yoshikawa (1990)

A. The Concept of EER

The concept of EER is similar to purchasing power parity (hereafter PPP). While the definition of PPP assumes that prices including those of not only tradable goods but also non-tradable goods will converge to a constant value between a home country and a foreign country, the EER proposed by Yoshikawa (1990) is the exchange rate which equalizes the price of tradable goods between a home country and a foreign country. In the tradable

[1]The proportion of trade volume to the U.S. and four Asian countries to the total volume in Japan expanded from 16% to 25% in 1990.

[2]Miyagawa and Toya (1999) and Kashiwagi and Sasaki (2000) measured the EER of won/yen rate based on the concept of Yoshikawa (1990).

goods sector, he assumed that both labor and raw materials are factors of production. Assumed fixed input coefficients for simplicity, the tradable goods price (P) of a home country can be expressed as follows,[3]

$$P=aW+bP_m \tag{1}$$

where a and b are labor input coefficient (the reciprocal of labor productivity) and the raw material input coefficient (the reciprocal of raw material productivity), respectively. W and P_m denote nominal wage and material prices, respectively. If the "law of one price in the international market" holds for the tradable goods price P and the imported raw material price P_m through the nominal exchange rate e, we can rewrite (1) as follows.

$$eP^*=aW+b(eP_m^*) \tag{2}$$

Here P^* and P_m^* are the prices of tradable goods and raw materials evaluated in a foreign currency, respectively.

Similarly, the price of tradable goods in a foreign country is formulated by (3).

$$P^*=a^*W^*+b^*P_m^* \tag{3}$$

From (2) and (3), we obtain EER as follows,

$$e=\left(\frac{W}{W^*}\right)\frac{[a/\{1-b(P_m^*/P^*)\}]}{\{a^*+b^*(P_m^*/W^*)\}} \tag{4}$$

The formula (4) shows that the EER is influenced by the nominal wage ratio (W/W^*), labor input coefficient (a and a^*), raw material input coefficient (b and b^*), and (the reciprocal of) the terms of trade (P_m^*/P^*). From (4), the rise (fall) of the nominal wage in home country or the fall (rise) of productivity in labor or the raw material input in the home country results in a depreciation (appreciation) in the home currency, and the rise (fall) of the terms of trade results in the appreciation (depreciation) of the home currency.

[3]Chipman (1971) showed that fixed production factor ratio was selected in the trade model that allowed that production factors are substitutable in the production function.

B. Calculating the EER

As we stated in the introduction, we calculate EER in China, Japan, Korea, Taiwan, Thailand, and the U.S. based on equation (4). The data series of the EER is from 1980 to 2003, except Taiwan, Thailand (from 1980 to 2000) and China (from 1985 to 2000), due to the inavailability of the data.

The first step in measuring the EER is to determine a base year. We set a base year when the current account is balanced. In a base year, EER is equal to the actual nominal exchange rate. Because the Asian countries that we examine became industrialized during the 1990s, we selected a base year in that decade. We calculated the three-year moving average of the current account of each country to smooth out the effects of business cycles, and picked the year with the smallest value as a base year for a country.

The next step is to calculate EER series based on equation (4). Because each factor in (4) is measured at different terms, we create their indices at 100 at the base year and generate the EER series. Regarding the labor and raw material coefficients in tradable goods, we choose eight manufacturing industries that dominate trade volume in each country textiles, chemicals, primary metals, metal products, general machinery, electrical machinery, transportation equipment, and precision instruments. Both the labor input coefficient and raw material input coefficient of each industry are average weighted by the export share of the above industries.[4] We transform the calculated index series into the EER in terms of currency by multiplying the indexed EER by the nominal exchange rate at the base year.

The results of calculation and actual exchange rates are summarized in Table 1. The data used for the calculation is summarized in the Appendix.

C. Evaluation of the EER

a) The EER of the Korean Won

Concerning the won/yen rate, the actual exchange rate and the EER fluctuated along the same trend in the first half of the 1990s.

[4]See the data appendix for the estimation method of each coefficient and the sources of the data.

TABLE 1

EQUILIBRIUM EXCHANGE RATE

	Korea (Base Year: 1990)						China (Base Year: 1993)			
	Won/Yen		Won/U.S.$		Won/Yuan		Yuan/Yen		Yuan/U.S.$	
	Actual	EER	Actual	EER	Actual	EER	Actual	EER	Actual	EER
1980	2.679	1.329	607.4	264.3	405.0	-	0.007	-	1.500	-
1981	3.088	1.377	681.0	237.1	398.3	-	0.008	-	1.710	-
1982	2.935	1.537	731.1	331.9	386.8	-	0.008	-	1.890	-
1983	3.266	1.950	775.8	378.1	391.8	-	0.008	-	1.980	-
1984	3.393	2.208	806.0	379.6	345.9	-	0.010	-	2.330	-
1985	3.647	2.614	870.0	459.9	296.3	158.6	0.012	0.018	2.937	2.463
1986	5.231	3.146	881.5	564.1	255.3	166.3	0.020	0.025	3.453	3.710
1987	5.687	3.999	822.6	645.3	221.0	164.6	0.026	0.019	3.722	3.431
1988	5.708	4.548	731.5	689.5	196.5	158.7	0.029	0.026	3.722	3.954
1989	4.867	4.944	671.5	740.2	178.3	161.2	0.027	0.036	3.765	5.229
1990	4.888	4.888	707.8	707.8	148.0	148.0	0.033	0.039	4.783	4.937
1991	5.444	5.409	733.4	788.0	137.8	154.9	0.040	0.043	5.323	5.387
1992	6.164	5.557	780.7	796.0	141.6	174.6	0.044	0.041	5.515	4.925
1993	7.218	6.226	802.7	832.5	139.3	155.5	0.052	0.052	5.762	5.762
1994	7.861	7.324	803.5	904.8	93.2	137.3	0.084	0.065	8.619	6.720
1995	8.200	7.512	771.3	858.9	92.4	106.2	0.089	0.075	8.351	7.244
1996	7.395	8.044	804.5	849.4	96.8	107.8	0.076	0.082	8.314	6.959
1997	7.863	7.291	951.3	808.1	114.8	102.6	0.069	0.077	8.290	6.894
1998	10.705	7.126	1401.4	895.2	169.3	93.8	0.063	0.079	8.279	8.001
1999	10.436	8.515	1188.8	1012.3	143.6	105.1	0.073	0.081	8.278	7.982
2000	10.494	8.507	1131.0	905.4	136.6	100.9	0.077	0.076	8.279	6.704
2001	10.623	7.722	1291.0	868.8	156.0	-				
2002	9.978	8.964	1251.1	1000.7	151.2	-				
2003	10.279	8.646	1191.6	829.0	144.0	-				

(Table Continued)

	Taiwan (Base Year: 1994)				Thailand (Base Year: 1993)				(Reference) Japan (Base Year: 1990)	
	New Taiwan Dollar/Yen		New Taiwan Dollar/U.S.$		Baht/Yuan		Baht/U.S.$		Yen/U.S.$	
	Actual	EER	Actual	EER	Actual	EER	Actual	EER	Actual	EER
1980	0.159	0.050	36.00	7.67	0.090	0.017	20.48	3.04	226.7	63.9
1981	0.167	0.056	36.84	7.33	0.099	0.019	21.82	3.08	220.5	63.0
1982	0.157	0.054	39.11	8.86	0.092	0.023	23.00	4.62	249.1	74.4
1983	0.169	0.060	40.06	8.88	0.097	0.027	23.00	4.86	237.5	81.4
1984	0.167	0.076	39.60	9.99	0.100	0.033	23.64	5.28	237.5	87.3
1985	0.167	0.085	39.85	11.71	0.114	0.040	27.16	6.52	238.5	92.9
1986	0.224	0.112	37.82	16.51	0.156	0.061	26.30	10.68	168.5	124.8
1987	0.220	0.146	31.77	20.45	0.178	0.081	25.72	13.29	144.6	154.9
1988	0.223	0.153	28.59	20.15	0.197	0.083	25.29	12.13	128.2	149.9
1989	0.191	0.164	26.40	20.71	0.186	0.086	25.70	11.94	138.0	150.6
1990	0.186	0.174	26.89	20.59	0.177	0.107	25.59	13.50	144.8	144.8
1991	0.199	0.185	26.81	21.72	0.189	0.145	25.52	17.94	134.7	143.2
1992	0.199	0.216	25.16	24.38	0.201	0.183	25.40	21.80	126.7	165.6
1993	0.237	0.240	26.38	25.56	0.228	0.228	25.32	25.32	111.2	174.7
1994	0.259	0.259	26.46	26.46	0.246	0.252	25.15	26.44	102.2	180.6
1995	0.281	0.266	26.48	25.43	0.265	0.287	24.92	28.59	94.1	170.5
1996	0.252	0.284	27.46	25.21	0.223	0.268	25.34	27.86	108.8	168.3
1997	0.237	0.353	28.66	31.75	0.259	0.349	31.36	33.17	121.0	168.9
1998	0.255	0.343	33.44	34.43	0.316	0.432	41.36	47.26	130.9	192.3
1999	0.283	0.311	32.27	29.86	0.332	0.428	37.84	45.11	113.9	210.7
2000	0.290	0.273	31.23	23.41	0.373	0.442	40.16	42.57	107.8	206.3
2001									121.5	197.8
2002									125.4	183.1
2003									115.9	180.6

This implies that the movements of actual won rate reflected economic fundamentals in Korea and Japan. The actual won/U.S. dollar rate and won/yuan rate also had the same trend as the EER before the Asian currency crisis in the same period. Though the gap between the two rates was not large, the overvaluation of the actual won against EER continued.

The Asian currency crises generated large gaps between the actual rates and the EERs for the won/yen, won/U.S. dollar, and won/yuan rates. These gaps remained in the 2000s. The actual won was 19% undervalued against the equilibrium won/yen rate in 2003, 44% undervalued against the equilibrium won/U.S. dollar rate in 2003, and 32% undervalued against the equilibrium won/yuan rate in 2000. Our estimate of the EER implies that the Asian currency crisis induced an excess adjustment of the won and this distortion has not disappeared.

b) The EER of the Chinese Yuan

Both the actual rate and the EER of the yuan/yen had depreciated until 1993. After 1994 when the yuan rate was pegged to U.S. dollar, the movement of the actual yuan/yen rate was parallel to that of the actual U.S. dollar/yen rate. Then the actual yuan rate was undervalued to the equilibrium yuan rate when the yen appreciated against U.S. dollar in the mid 1990s. Conversely, the actual yuan rate was overvalued to the equilibrium yuan rate when the yen depreciated against U.S. dollar in 1997-8, when Japan suffered from the collapse of the financial system. However, both rates converged in 2000.

Concerning the yuan/U.S. dollar rate, the gap between the actual rate and the EER has widened since 1994 when the yuan was pegged to the U.S. dollars. Basically, the actual yuan rate was undervalued to the equilibrium yuan rate. In 2000, the gap was about 25%.[5]

c) The EER of Other Currencies

There is no big gap between the actual exchange rate and the

[5]Recently, Akama, Mifune, and Noro (2002) measured purchasing power parity (PPP) between China and Japan setting the base year at 1993. Hirose and Morito (2003) and the Japan Center for Economic Research (2004) measured the EER between yuan and yen.

EER of new Taiwan dollar/yen in the first half of the 1990s. Although the actual exchange rate of new Taiwan dollar tended to be overvalued in the second half of the 1990s, the gap between actual rate and the EER which widened during the Asian currency crisis was reduced as the actual exchange rate depreciated after the crisis. The actual exchange rate and the EER of the new Taiwan dollar/U.S. dollar moved along a similar path from the first half of the 1990s to 1998. Therefore, we believe that the depreciation of the new Taiwan dollar/U.S. dollar after the Asian currency crisis was not explained by economic fundamentals.

The actual baht rates against the yen were overvalued to EER in the 1990s. The actual baht/U.S. dollar rate was overvalued to EER in 1998 and 1999, though it converges to EER in 2000. In contrast to the case of the new Taiwan dollar, we believe that the large depreciation of baht the against the yen and the U.S. dollar in the Asian currency crisis reflected economic fundamentals.

III. Factors Affecting the EER: Factor Prices and Productivity Differences

As we observed in the last section, several actual exchange rates fluctuated along the same trends as the EERs. This implies that the actual exchange rate is affected by economic fundamentals as the movement of productivity and wage rates. Conversely, when there is a gap between the two rates, the actual exchange rate does not reflect economic fundamentals and the gap generates biases in international competitiveness.

The movements of the EER are affected by several factors that define the EER. To check which factor is crucial in the movement of EER, we construct the simulated equilibrium exchange rate (hereafter SER) which focuses on a specific factor in EER and compare it to the EER.[6] An example of SER is expressed as follows.

[6]If we decompose the growth rate of the EER into growth rates of all factors in the EER, we can find the effects of all factors. However, because the large mixed effects among these factors in the EER generated from the decomposition of Equation (4) prevail over effects of a specific factor, we choose the simulation which focuses on a specific factor.

$$e_{SER} = \left(\frac{\bar{W}}{\bar{W}^*} \right) \frac{[a/\{1-\bar{b}(\bar{P}_m^*/\bar{P}^*)\}]}{\{a^*+\bar{b}^*(\bar{P}_m^*/\bar{W}^*)\}} \tag{5}$$

Equation (5) is a SER which focuses on the changes in the differences in labor productivity. In (5), as other factors except a and a^* are fixed at the base year, we can check the movement of the EER that can be explained by labor productivity difference in both countries. For example, if the SER in (5) is on an appreciating trend, we understand that higher labor productivity growth in the home country can cause the EER to appreciate. We choose PPP in terms of wage rates (W/W^*), labor productivity differences, and material productivity differences as crucial factors in the movement in EER. Our comparisons between EER and SER are summarized in Table 2.

A. Comparison between the EER and SER of the Korean Won

In Table 2-1, Table 2-2, and Table 2-3, we summarize our simulation results on the won rate. For the won/yen rate, the table shows that the movement of PPP in terms of wage rate had the same trends as the EER though PPP in 2003 was undervalued against the EER. The results are in contrast with the case of the EER of the yen/U.S. dollar studied by Yoshikawa (1990) that showed the gap between the EER and PPP to be very large. However, the result does not mean that productivity differences between Korea and Japan played no role on the movement in the EER. The simulation shows that the rise of the Korean labor productivity in this period had a large effect on the won. On the other hand, the SER which focused on material productivity differences had the same trend as PPP and has contributed to the depreciation of the won. As a result, as the rapid growth in Korean labor productivity was offset by increases in Japanese raw material productivity, the movement of the EER has moved along with PPP.

In the case of the won/U.S. dollar rate, the results are similar to the case of the won/yen rate. Like the won/yen rate, the won in the EER and PPP have devalued together. In addition, the won in PPP was more devalued than the won in the EER in 2003. The Korean labor productivity growth was almost offset by the U.S. raw material productivity growth.

TABLE 2-1

SIMULATED KOREA-JAPAN EQUILIBRIUM RATES (BASE YEAR: 1990)

	Actual Rate	EER	SER		
			Labor Productivity Difference	Material Productivity Difference	Wage Rate Difference
1980	2.679	1.329	12.998	2.151	1.775
1985	3.647	2.614	8.017	4.155	2.680
1990	4.888	4.888	4.888	4.888	4.888
1995	8.200	7.512	2.453	7.426	8.455
2000	10.494	8.507	1.506	10.272	11.190
2003	10.279	8.646	1.242	10.374	14.221

TABLE 2-2

SIMULATED KOREA-U.S. EQUILIBRIUM RATES (BASE YEAR: 1990)

	Actual Rate	EER	SER		
			Labor Productivity Difference	Material Productivity Difference	Wage Rate Difference
1980	607.4	264.3	1829.2	356.9	295.5
1985	870.0	459.9	1168.4	578.3	392.0
1990	707.8	707.8	707.8	707.8	707.8
1995	771.3	858.9	413.1	761.3	1116.5
2000	1131.0	905.4	280.7	966.6	1291.3
2003	1191.6	829.0	231.5	989.2	1437.7

TABLE 2-3

SIMULATED KOREA-CHINA EQUILIBRIUM RATES (BASE YEAR: 1990)

	Actual Rate	EER	SER		
			Labor Productivity Difference	Material Productivity Difference	Wage Rate Difference
1980	405.0	-	-	-	-
1985	296.3	158.6	207.4	150.8	125.9
1990	148.0	148.0	148.0	148.0	148.0
1995	92.4	106.2	125.8	150.2	113.3
2000	136.6	100.9	159.8	141.7	93.3

TABLE 2-4

SIMULATED CHINA-JAPAN EQUILIBRIUM RATES (BASE YEAR: 1993)

	Actual Rate	EER	SER		
			Labor Productivity Difference	Material Productivity Difference	Wage Rate Difference
1980	0.007	-	-	-	-
1985	0.012	0.018	0.100	0.035	0.022
1990	0.033	0.039	0.086	0.040	0.034
1995	0.089	0.075	0.049	0.051	0.076
2000	0.077	0.076	0.018	0.085	0.122

TABLE 2-5

SIMULATED CHINA-U.S. EQUILIBRIUM RATES (BASE YEAR: 1993)

	Actual Rate	EER	SER		
			Labor Productivity Difference	Material Productivity Difference	Wage Rate Difference
1980	1.500	-	-	-	-
1985	2.937	2.463	9.367	4.403	2.684
1990	4.783	4.937	8.737	5.392	4.124
1995	8.351	7.244	5.536	5.029	8.499
2000	8.279	6.704	2.168	8.192	11.931

TABLE 2-6

SIMULATED TAIWAN-JAPAN EQUILIBRIUM RATES (BASE YEAR: 1994)

	Actual Rate	EER	SER		
			Labor Productivity Difference	Material Productivity Difference	Wage Rate Difference
1980	0.159	0.050	0.411	0.122	0.106
1985	0.167	0.085	0.388	0.160	0.137
1990	0.186	0.174	0.317	0.210	0.198
1995	0.281	0.266	0.249	0.266	0.265
2000	0.290	0.273	0.190	0.327	0.300

TABLE 2-7

SIMULATED TAIWAN-U.S. EQUILIBRIUM RATES (BASE YEAR: 1994)

	Actual Rate	EER	SER		
			Labor Productivity Difference	Material Productivity Difference	Wage Rate Difference
1980	36.00	7.67	33.90	17.14	13.85
1985	39.85	11.71	32.82	20.12	15.78
1990	26.89	20.59	27.16	27.49	22.58
1995	26.48	25.43	25.77	25.37	27.55
2000	31.23	23.41	21.62	29.95	27.23

TABLE 2-8

SIMULATED THAILAND-JAPAN EQUILIBRIUM RATES (BASE YEAR: 1993)

	Actual Rate	EER	SER		
			Labor Productivity Difference	Material Productivity Difference	Wage Rate Difference
1980	0.090	0.017	0.311	0.038	0.133
1985	0.114	0.040	0.280	0.083	0.129
1990	0.177	0.107	0.229	0.176	0.148
1995	0.265	0.287	0.223	0.245	0.258
2000	0.373	0.442	0.241	0.300	0.302

TABLE 2-9

SIMULATED THAILAND-U.S. EQUILIBRIUM RATES (BASE YEAR: 1993)

	Actual Rate	EER	SER		
			Labor Productivity Difference	Material Productivity Difference	Wage Rate Difference
1980	20.48	3.04	28.98	6.06	18.83
1985	27.16	6.52	28.80	11.37	15.96
1990	25.59	13.50	22.01	24.25	18.12
1995	24.92	28.59	26.22	23.92	28.88
2000	40.16	42.57	32.57	28.58	29.51

The case of the won/yuan differs from the previous two cases. Because the labor productivity growth in Korea was slower than that in China, the EER in terms of won appreciated slower than PPP measured by the wage rate. The appreciation of the EER of the won/yuan rate was caused not by a higher productivity growth in Korea but by a higher wage growth in China.

B. Comparison between the EER and SER of the Chinese Yuan

In the case of the yuan, PPP was more depreciated than EER in both the yuan/yen and the yuan/U.S. dollar rates. This implies that Chinese wage growth was faster than those in Japan and the U.S.. However, the rapid growth of Chinese labor productivity curbed the devaluation of the yuan/yen rate and the yuan/U.S. dollar rates. The SER, which focused on labor productivity differences, has contributed to the appreciation of the yuan against the yen and the U.S. dollar. This effect dominated the devaluation effect of the yuan induced by raw material productivity differences.

C. Comparison between the EER and SER of Other Currencies

Table 2-6 and Table 2-7 show the sources of EER movements in the new Taiwan dollar. As we found in the case of previous currencies, while labor productivity growth in Taiwan induced the appreciation of the new Taiwan dollar, raw material productivity growth contributed to the depreciation of new Taiwan dollar. In the case of new Taiwan dollar/yen, the effects of raw material productivity growth dominated labor productivity growth and EER was depreciated from 1995 to 2000. On the contrary, in the case of the EER in the new Taiwan dollar/U.S. dollar case, the EER appreciated as the former effect dominated the latter.

In Tables 2-8 and 2-9, the movements of PPP in the Thai baht was different from those in the Korean won, Chinese yuan, and new Taiwan dollar. The EERs in both cases of baht/yen and baht/U.S. dollar were undervalued against PPP and all SERs. The result implies that total effects of wage differences and productivity differences contributed to the devaluation of the EER.

IV. Alternative Measurements of the EER

The concept of the EER examined by Yoshikawa (1990) is based on several assumptions. We confirm the above results by changing these assumptions. In addition to the basic model, we will consider the following three cases; a difference in cost of capital between two countries, adding service input, and an "effective" EER that takes into multilateral trade.

A. Differences in Costs of Capital

In the basic model, we did not consider capital service input on production activities, because costs of capital in two countries are equalized in the long run due to the perfect international capital flow, and the difference in capital coefficients in two countries were assumed not to affect EER to a large degree. However, as Feldstein and Horioka (1980) have shown, it is hard to say that domestic investment behavior is affected by the free movement of international capital. In addition, China has maintained restrictions of capital inflow and outflow. Statistical data also show that the capital coefficient (efficiency of capital) indicates an upward trend from the 1970s in Japan, while it has been stable in the U.S., and the gap between the two coefficients have recently widened.

Therefore, we remove the assumption that the costs of capital are equalized due to the free international movement and measure an alternative EER that includes capital service as a factor of production. When capital is included, the tradable goods price in the home country can be expressed as follows.

$$P = aW + bP_m + cR \tag{6}$$

Here c is the capital coefficient and R is the cost of capital. Similarly the tradable goods price of a foreign country is defined by

$$P^* = a^*W^* + b^*P_m^* + c^*R^* \tag{7}$$

From (6) and (7), the equilibrium exchange rate including capital service as input is

$$e_k = \left(\frac{W}{W^*}\right)\frac{[\{a+cq\}/\{1-b(P_m^*/P^*)\}]}{\{a^*+b^*(P_m^*/W^*)+c^*q^*\}} \tag{8}$$

In (8), q is the factor price ratio (cost of capital (R)/wage (W)). From equation (8), both relative rises (declines) of the capital coefficient and the cost of capital will lead to a depreciation (appreciation) of the domestic currency in the EER.

To construct an alternative measure of EER, we need a data series of the capital coefficient and cost of capital. However, it is difficult to use these data in the case of China. Hence we can calculate cq based on the following equation in all countries and areas.

$$cq = \frac{K}{Y}\cdot\frac{R}{W} = \frac{UCC}{W} \tag{9}$$

We pick up the portion of the operating surplus from the Input-Output Table, compute the unit capital cost (UCC), and measured e_k. The details of data are stated in the Appendix.

The results of the measurement in the EER for China, Korea and Japan are described in Figure 1 and Figure 2.[7] In these figures, we show the series of the actual exchange rate and the EER in the basic case for reference.

In Figure 1, though the gap between the EER including capital service and the actual won/yen rate widened during the Asian currency crisis, the EER including capital service has converged to the actual rate.[8] The result reflects the fact that the yen has been appreciating against the won in the EER, because the zero interest policy since the late 1990s in Japan induced the Japanese cost of capital relatively low.

Next, we check the movements of the EER in the yuan/yen. The gap between EER including capital service and the actual exchange

[7]Regarding capital service input, we also measure the EER of other cases (for example, the case of the won/U.S. dollar and the yuan/U.S. dollar). If the reader is interested in the EER series in the other cases, we can send these results on reader's request.

[8]Concerning the won/U.S. dollar rate, the gap between the EER including capital service input and the actual rate also tended to converge.

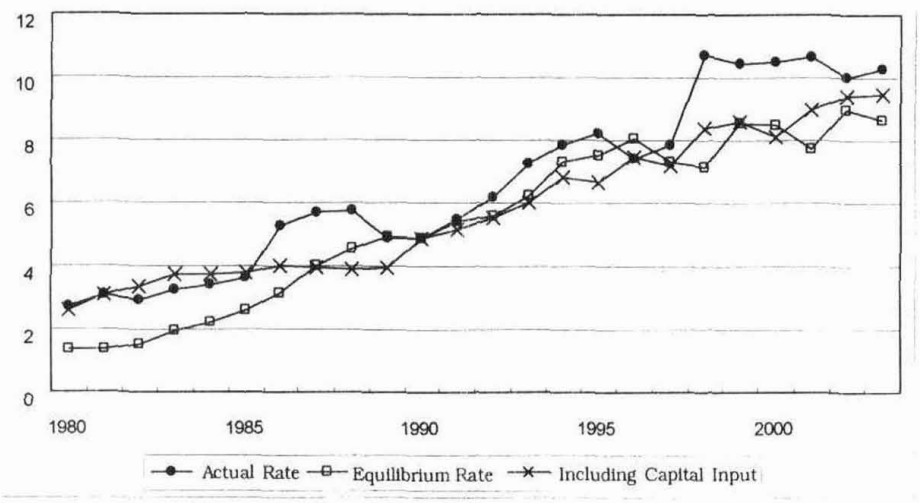

FIGURE 1
KOREA-JAPAN EQUILIBRIUM EXCHANGE RATE (WON/YEN)
BASE YEAR: 1990

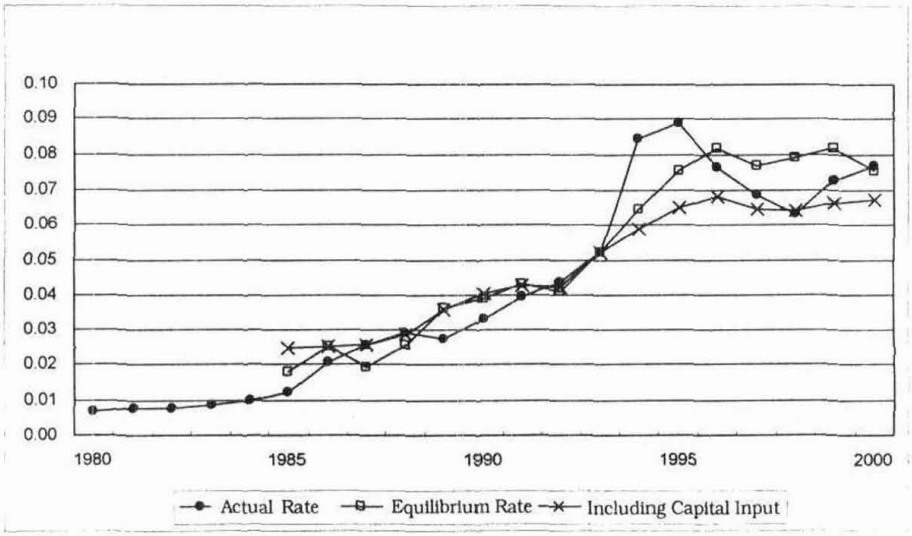

FIGURE 2
CHINA-JAPAN EQUILIBRIUM EXCHANGE RATE (YUAN/YEN)
BASE YEAR: 1993

rate grew in the mid 1990s when the yen appreciated. After the gap converged in 1998, it has widened again.

B. Incorporating Service Input

The international competitiveness of tradable goods is affected by not only productivity differences of labor or raw materials but also by the price in non-tradable goods. In the 1990s, many economists pointed out that Japanese international competitiveness deteriorated due to the high prices in the non-tradable sector. By focusing on the service sector, we examine the effects of the non-tradable sector on the movement of the EER.

We assume that labor is the only production factor in the service sector, because the production technology of service sector can be considered to be labor-intensive. Suppose that the inter-sectoral movement of labor is free and the wage rate is equalized in each industry. Then, modified EER (e_s) can be expressed as follows.

$$e_s = \left(\frac{W}{W^*} \right) \frac{\{[a+gh]/\{1-b(P_m^*/P^*)\}\}}{\{a^*+b^*(P_m^*/W^*)+g^*h^*\}} \tag{10}$$

In (10), g is a service input coefficient in the tradable goods sector and h is the labor input coefficient in the service sector. If g and h in a home country rise in (9), a home currency's EER will depreciate and vice versa.

Due to the availability of the data in the service sector, we can only measure the EER of the won/yen rate.[9] According to Figure 3, the won in the EER that incorporates the input from the service sector had depreciated more than the won in the basic EER. While the actual won rate was undervalued in 2000 compared to the basic EER, it was overvalued compared to the EER with the input from the service sector. We believe that in addition to the lower productivity of the Korean service sector, the increase of inputs from the service sector in Korea in the 1990s lowered the EER that incorporated service sector inputs. The low productivity in the service sector was pointed out not only in Korea but also in Japan. That is, if the tradable goods sector attained higher productivity

[9]We also measured EER with service input for the won/U.S. dollar rate. We can also send this series upon the request of the reader.

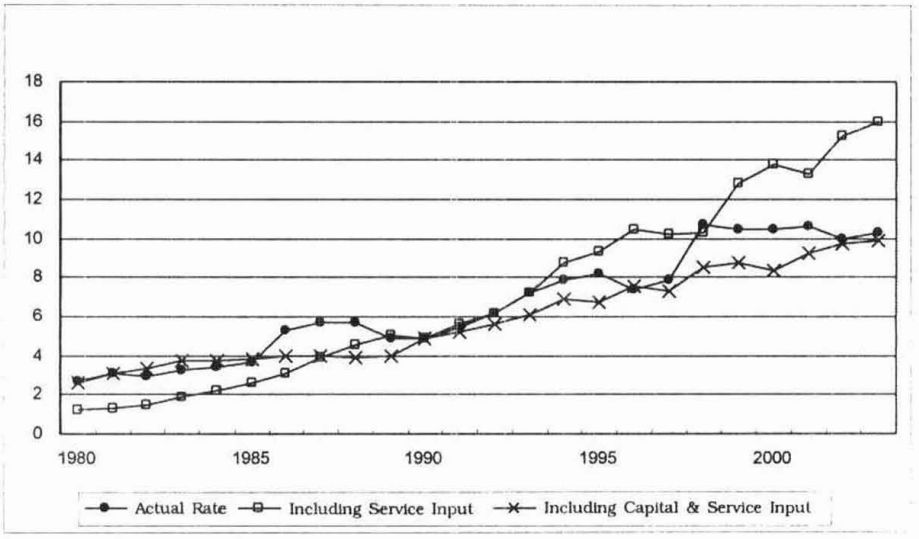

FIGURE 3
KOREA-JAPAN EQUILIBRIUM EXCHANGE RATE (WON/YEN)
BASE YEAR: 1990

than the non-tradable goods sector, the actual won is likely to be overvalued. As a result, Korea as well as Japan may be suffering from the price differential between the domestic and overseas markets.

If we consider both EERs with capital service and the input from the service sector together, the EER in 2003 converged to the actual won/yen rate. The result implies that the recent actual won/yen rate is affected by economic fundamentals that reflect not only labor and material productivity differences but also differences in efficiency in the service sector and cost of capital. While the rapid labor productivity growth in Korea resulted in the won appreciating against the yen, the effect was totally offset by the wage increase, the inefficiency in the service sector in Korea, and the low cost of capital in Japan.

C. Measuring the Effective Equilibrium Exchange Rate

We have defined the EER as the exchange rate where international competitiveness is equalized in bilateral trade. However, in the real world, the trade of goods is carried out among many countries and bilateral competitiveness is not equalized in the long

run. If we remove the assumption that goods are traded between two countries, the long-term bilateral exchange rate may not correct the imbalances in trade. Even if the actual exchange rate against a specific currency converges to the EER, the actual exchange rate against another currency may diverge from another EER.

Here we attempt to calculate weighted average of the EER constructed between two countries weighted by trade, as the "effective" equilibrium exchange rate. The steps to calculate effective EER are as follows.

(1) We use the basic type of EER in each currency to construct the effective EER, due to data availability.
(2) Each EER is indexed. The base year is 1990 and we set the index value in 1990 at 100.[10]
(3) We provide two types of the trade weight. One is the fixed weight in 1990, the other is the flexible weight using annual trade weights. Since we are constructing the Japanese effective equilibrium exchange rate, we use *Foreign Trade Outlook* of the Ministry of Finance, Government of Japan as our data source for trade weights.[11]
(4) The Effective equilibrium exchange rate is constructed as the weight averaged series of each EER.

Our effective EER is not constructed by covering all trade partners in Japan. However, the trade volume (export+import volume) with China, Korea, Taiwan, Thailand and the U.S. accounted for 43.6% of the whole trade volume in Japan in 1990. We believe that this proportion has increased recently and it is possible to calculate the effective EER.

The series of the effective EER of Japan is described in Figure 4. In Figure 4, we show not only the effective EER of Japan, but also the nominal effective exchange rate of Japan using the same trade weights at our measurement of effective EER, and the nominal

[10]The year when the lowest current account/GDP ratio was recorded differs by country. However, we set 1990 the base year when Japan recorded the lowest current account/GDP ratio because we are measuring effective EER of the yen.

[11]Trade weights are endogenous in the sense that they are affected by the exchange rate. Hence we measure the effective EER with fixed trade weights in addition to the effective EER with variable trade weights.

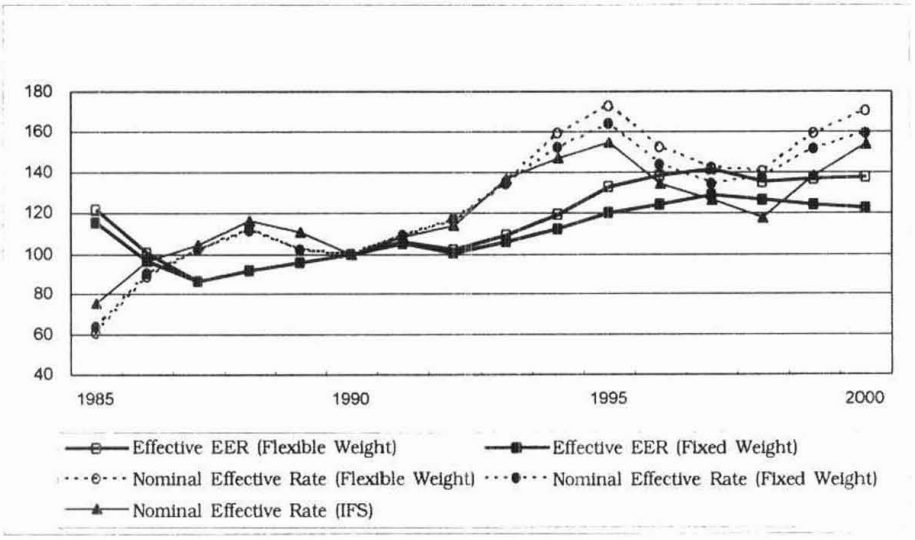

FIGURE 4
EFFECTIVE EQUILIBRIUM EXCHANGE RATE (1990=100)

effective exchange rate of IMF statistics (*International Financial Statistics*). When the yen appreciates, the effective EER takes a higher index value in Figure 4.

The nominal effective exchange rate calculated by trade weights to the U.S. and Asian countries and the nominal effective exchange rate of IMF statistics followed a similar trend. Hence, we focus on the movements of the effective EER and nominal effective exchange rate that we calculated.

Since the actual yen rate appreciated against the U.S. dollar in the first half of the 1990s, the nominal rate became overvalued greatly to the effective EER. However, during the crisis in the Japanese financial system in 1997-8, the yen depreciated against the U.S. dollar and yuan that was pegged to U.S. dollar. Then, the gap between the nominal rate and the effective EER contracted. The nominal rate has become overvalued again to the effective EER since 1999, because the actual yen/U.S. dollar rate became overvalued to the EER in yen/U.S. dollar rate, and actual yen rates are almost equal to the EER of Chinese yuan, the Korean won, and the new Taiwan dollar. In 2000, the nominal rate was overvalued by about 30% on a fixed weight, and 24% on a flexible weight,

compared to the effective EER. In the bilateral trade cases for China, Korea, and Taiwan, the gaps between the nominal rates and the EER are not so large. However, under the assumption of the multilateral trade model, the yen needs to depreciate by about 24% to 30%.

V. Conclusions and Future Research Topics

International competitiveness in Japanese industries is the center of attention because it is one of the crucial factors behind the long-term stagnation in the Japanese economy, and the deterioration of international competitiveness in Japanese industries has resulted in low productivity growth. The measurement of international competitiveness depends on whether the actual exchange rate reflects economic fundamentals such as factor prices and productivity differences. In particular, whether exchange rates among Asian countries reflect appropriate international competitiveness has become a hot discussion topic, due to the large current surplus of China and the FTA boom in Asian countries.

Regarding the above topics, we propose the equilibrium exchange rate as an exchange rate that reflects economic fundamentals, and we measure them for five Asian countries and the U.S.. Our results of the estimation are summarized as follows.

(1) Korea: There was little gap between the EER of the won/yen rate in the basic case and the actual rate until the Asian currency crisis. Concerning the won/U.S. dollar and won/yuan rates, the overvaluation of the actual won against the EER continued until the Asian currency crisis. The Asian currency crisis resulted in the large undervaluation of the actual rate against the EER for all currencies. The undervaluation remained until 2003. In 2000, the actual won was undervalued by about 19-44% against the EER in the case of the yen, the U.S. dollar, and the yuan.
(2) China: Since the middle of the 1990s, the actual yuan rates against both the yen and the U.S. dollar have been undervalued to the EER. However, in 2000, the actual exchange rate and the EER of yuan/yen are almost at the same level.
(3) Taiwan: Although the gap between the EER and the actual

exchange rate of the new Taiwan dollar/yen existed temporarily during the Asian currency crisis, the gap has almost disappeared. However, in the case of new Taiwan dollar/U.S. dollar rate, the actual new Taiwan dollar rate is somewhat undervalued as of 2000.

(4) Thailand: In the case of the baht/yen rate, the gap between the EER and actual rate has widened after the Asian currency crisis, and the actual baht rate is overvalued as of 2000. On the other hand, in the case of baht/U.S. dollar rate, there is no divergence between the two rates in spite of the Asian currency crisis.

(5) Checking the factors behind the movements in the EER, we found that nominal wage rates and productivity differences between two countries played important roles in the movement in EER. In the case of the won, PPP measured by wage rates had the same trend as the EER in all cases. Labor productivity growth in Korea was offset by raw material growth in Japan or U.S.. In the case of the yuan, rapid labor productivity growth restrained the devaluation of yuan induced by the rapid wage growth in China.

(6) Considering the difference in costs of capital between two countries, the actual won and yuan rate tended to be undervalued to the EER in the 2000s.

(7) Measuring EER with the input from the service sector - that is likely to affect the international competitiveness of the tradable goods, - the won depreciated against the yen. This implies there exists a price differential between the domestic and overseas markets inherent in Korea. Due to this effect and the low cost of capital in Japan, the effect of labor productivity growth in Korea is offset.

(8) We constructed the effective EER under a multilateral trade model. Comparing the effective EER and the actual effective exchange rate, the actual effective rate of yen is overvalued by 24% to 30% to the effective EER as of 2000.

Our analysis offers a useful index a desirable long-term exchange rate. The index is also useful for judging the validity of intervention in international financial markets by monetary authorities. Furthermore, using the gap between the actual rate and the EER, the government can check whether a FTA with a specific foreign

country is advantageous for a home country.

We can carry out the following extension to improve our analysis. Firstly, when we create the EER incorporating capital service input, we used the operating surplus as the proxy for unit capital cost, but this reflects the accurate cost of capital only partially. By estimating the capital stock of major trading partners of Japan, it would be possible to construct a more accurate EER with capital service input. Secondly, we have assumed that the industrial structures of home and foreign countries were same. However, industrial structures of the Asian countries are rapidly changing, and they are in various stage of development. It will be necessary to analyze how the EER is affected by the differing stages of development or industrial structures. Finally, the gap between an actual exchange rate and the EER affects several international economic variables such as the trade structure in two countries, foreign direct investment behavior, and international capital movement. We will check the relationship of EER to these variables.

Appendix: Estimation Method of the Data

The following variables are used in our calculation of the equilibrium exchange rate.

(1) Labor input coefficient
(2) Raw material input coefficient
(3) Service input coefficient
(4) Unit capital cost
(5) Nominal wage
(6) Raw material price
(7) Export price
(8) Export share.

The sample period of all variables is from 1980 to 2003, except Taiwan, Thailand (from 1980 to 2000) and China (from 1985 to 2000) due to the availability of the data. We describe the estimation method of the variables (1)-(8).

(1) Labor input coefficient: $a=\sum_i \sigma_i a_i$

The labor input coefficient of the manufacturing industry, we

used the weighted average of the labor input coefficient a_i in each sector. This is calculated by dividing the number of workers by real production. The weights used for the calculation is the export share in each sector (σ_i: we discuss in detail later). The sectors we used were fibers, chemical, primary metals, metal products, general machinery, electrical machinery, transportation equipment, and precision instrument.

Regarding Korea, in order to take service inputs into consideration, the labor input coefficient of Japanese and Korean service industry is needed. Because the labor input coefficient of service industry (h) in Japan, and Korea is not broken down by sector such as the manufacturing industry, we created the labor input coefficient by means of dividing the number of workers in the total service industry by the real value added of the total service industry.

(2) Raw material input coefficient: $b=\sum_i \sigma_i[b_{i.O}+b_{i.PETRO}\times b_{PETRO.O}]$

a. First, the direct input coefficient is calculated by (Input from the mining industries into each manufacturing sector)/(Production of each manufacturing sector) ($b_{i.O}$).
b. Second, the indirect input coefficient which is calculated by multiplying the input coefficient: (Input from petroleum and coal products into each manufacturing sector)/(Production of each manufacturing sector), by the input coefficient: (Input from the mining industries into the petroleum and coal products sector)/(Production of the petroleum and coal products sector) ($b_{i.PETRO}\times b_{PETRO.O}$).

They are weighted by the export shares in the same way as the labor input coefficient variables. When the data is not available on an annual basis, we estimate it by linear interpolation.

(3) Service input coefficient: $g=\sum_i \sigma_i g_i$

This is the weighted average of the input coefficient (Input from service industry into each manufacturing sector)/(Production in each manufacturing sector) by export share. When the data is not available on an annual basis, we estimate it by linear interpolation.

(4) Unit capital cost: $UCC=\sum_i \sigma_i UCC_i$

Although it would be desirable to use the operating surplus form the Input-Output Table for the unit cost of capital in the manufacturing industry, the Input-Output-Table is not available for every year.

Thus, we use the Survey of Manufacturing data, and calculate the value (Nominal value added-Compensation of employee)/(Real production) and take a weighted average by export share in each sector.

(5) Nominal wage: W

This is average nominal wage of the manufacturing industry. When only the wage levels are available, we create an index series for the value.

(6) Raw material price: P_m

Since the "law of one price" holds, raw material price is the same value in each country. Therefore, to estimate the yen (dollar) rate of each country, we use the wholesale price index (implicit deflator) of petroleum and coal products in Japan (U.S.).

(7) Export price: P

Same as in the above case, to estimate the yen (dollar) rate of each country, we use the export price index (implicit deflator) of manufacturing goods in Japan (U.S.).

(8) Export share: $\sigma_i=X_i/\sum_i X_i$

The export share is the value obtained when we divided the export value (the same sector as labor input coefficient X_i) of each sector by the total export value of each sector ($\sum_i X_i$).

When we estimate the equilibrium exchange rate for any two nations, we use the same export share (home country) for both countries as weights, in order to average the labor input and raw-material input coefficient of each sector. By doing so, we expect to be able to remove the effects of the differences of export (industry) structure in the two countries.

The export share of Japan is taken from the *Annual Report on National Accounts* (ESRI, Cabinet Office). The export share of each country other than Japan until 1996 was obtained from *Gaikoku Boueki to Keizai Hatten (Foreign Trade and Economic Development)* (Asia information center, Takushoku University, 2000, in Japanese), and since 1997 we can obtain the export share data from ITC's (International Trade Centre) Web Site (http://www.intracen.org/tradstat/welcome.htm).

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